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SUPPORT OF NATIONAL RESEARCHER CONSULTATION FOR THE PULSE CANADA RESEARCH STRATEGY DEVELOPMENT

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Pulse Canada Research Strategy Background Document

Ideas and Suggestions developed by the Quality & Utilization, Genetic Improvement, Agronomy and Sustainable Environment Committees.

November, 2001

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ABSTRACT OF BACKGROUND DOCUMENT:

The Canadian Pulse Industry has grown rapidly in recent years and is now valued at over one billion dollars per year. Beyond the production and value of sales, pulse crops provide a higher net return to producers, environmental benefits, increased quantity and quality of crops following the pulses in the rotation, and value added processing opportunities. Funding of pulse research has not grown to keep up with the expansion of the industry. The goal of the research strategy is to develop a map of what research is required to support the pulse industry and how to achieve this by working together.

During the past eleven months, committees consisting of 53 scientists from across Canada have worked to develop ideas for a strategy in the areas of quality & utilization, genetic improvement, agronomy and sustainable environment. The ideas and suggestions developed by these committees are compiled in the attached background document and are to be used as a starting point for discussion at the research strategy workshop.

The total cost associated with carrying out the suggested research is estimated at $25 million per year. This would require increasing funding by $ 10 million per year above the $ 15 million per year currently allocated to pulse research. A yearly research cost of $25 million equals only 2% of the value of the 2001 pulse crop, a small reinvestment back into a highly valuable and growing industry that provides a high rate of return to Canadians. An expenditure of $22 million also is required to enhance the infrastructure required for to carry out these programs. Limited and short-term funding in the past has resulted in a shortage of scientist working on pulse crops as well as inadequate facilities and equipment.

The research in pulses has been fragmented and incomplete, especially in quality and utilization, sustainable environment and in the areas of agronomy and genetic improvement. Current efforts are sporadic and limited in comparison to cereals and oilseeds. All areas of research in lentils and chickpeas are under funded and of insufficient scale when considering the value of these crops to Canada. Additional research activities are needed to facilitate the expansion of peas and beans into new regions.

Before the research needs can be addressed, it is essential to establish a foundation of people, infrastructure and baseline research required to do the job. There is a need to establish the following positions: a lentil breeder and pathologist, a chickpea breeder and pathologist, a breeding program in Edmonton for the short season region (peas), a bean breeder and pathologist in Morden as well as several technicians to support the proposed network of quality and utilization, agronomy and sustainable environment research. A network of Canadian research locations, with qualified staff, is required to perform crop line screening, disease screening, pest management research, other agronomic studies and sustainable environment studies. A new facility is needed to house the chickpea and lentil research programs. Some capital investment will be required to support the new positions listed above. Some baseline research and database development is also required, especially for quality and utilization research. Yearly compositional and component measurements are required to provide a record of what is produced in Canada, for marketing information and also as a support system for the genetic improvement programs. Currently there is limited long-term quality support commitment for the genetic improvement programs. Some initial research is required to determine the initial baseline and methodology required for quality measurements. Market intelligence is required to gather information on the current uses and markets of Canadian pulses as well as to provide future projections that can be utilized as guidance tools for research.

The total number of pulse researchers is conservative, however, they would be able to support the research needed if institutions allow researchers to work together. This requires that research and work remain open and available regardless of where or how it is performed. For the betterment of the industry, pulse research should be a team effort across Canada and, in some cases, across the global.

The suggested research activities are as follows:

1. Quality & Utilization

The important areas of research that need to be addressed in quality & utilization are:

- Pulse starch utilization
- Pulse flour utilization
- Whole seed processing
- Studies looking for and evaluating nutraceutical type components
- Evaluating feeding value of pea
- Effect of processing on feed

2. Genetic improvement

- Genetic improvement objectives have been developed for the crops and their classes
- Biotechnology priorities were identified and obvious weaknesses werre found that need to be addressed.
- A new crop and market class genetic development plan needs to be developed where the genetic improvement centres work together to develop new pulses in the regions where they will likely find the greatest success.
- Develop a germplasm pool source.

3. Agronomy

The areas of concentrated research are suggested to be in:

- Pest management (disease & weeds, IPM, minor use registration, development of a sporadic pest research fund)
- Quality improvement through production systems
- Plant nutrition - inoculation and fertilization
- Risk reduction systems – determine the economic implications for producers in research

4. Sustainable Environment

Research is required across all climatic regions in Canada to determine:

- The impact of pulses on greenhouse gas and climate change
- The long-term environment impact and management of pulses
- The long-term impact of pulses in the cropping system and how to manage the whole system to enhance economics

Much of this research would be added to and work in conjunction with shorter-term studies as suggested in agronomy.

The workshop will provide an opportunity to examine and add to these ideas. The next steps of implementing the strategy will have to be developed as well.

TABLE OF CONTENTS:

Topic Page -

Pulse Research Strategy Background 1
- The Reason For A Strategy 1
- Canada- A World Leader In The Pulses 1
- Pulse Crops Are Valuable To Canada 1
- Trends In The Pulse Industry 2
- Future Markets For Pulses 3
- The Start 3
- General Ideas Suggested 4
- Pulse Research Requires A Foundation 4
- Ideas For Research Areas 5

Quality & Utilization Strategy Suggestions 6
- 1. Special Characteristics Of Pulse Crops That Must Be Recognized For Quality And Utilization Research 6
- 2. Current State Of Quality & Utilization Pulse Research 6
- 3. Foundation Requirements For Quality And Utilization Research 6
- 4. Issues In Quality And Utilization Research 7
  - 4.1 Quality 7
  - 4.2 Utilization 12
- 5. Important Research Areas For Quality And Utilization 15
- 6. Continues Strategy Development Steps 15

Genetic Improvement Research Strategy Suggestions 16
- 1. Special Characteristics Of Pulses Crops That Must Be Recognized For Genetic Improvement 16
- 2. Current State Of Genetic Improvement Research In Pulses 16
- 3. Foundation Requirements For Genetic Improvement Research 17
- 4. Objectives For Genetic Improvement 20
- 5. Continued Strategy Development Steps 22

Agronomy Research Strategic Suggestions 23
- 1. Special Characteristics Of Pulse Crops That Must Be Recognized For Agronomic Research 23
- 2. Current State Of Agronomic Research In Pulses 23
- 3. Impact Of Changes In The Industry 23 24
- 4. Foundation Requirements For Agronomic Research 24
- 5. Issues In Agronomy 25
  - 5.1 Peas 25
  - 5.2 Lentils 26
  - 5.3 Dry Beans 27
  - 5.4 Chickpeas 28
  - 5.5 New Crops 29
  - 5.6 Weed Management 29
  - 5.7 Integrated Research 29
- 6.0 Continued Strategy Development Steps 32

Environmental Sustainability Research Strategic Suggestions 33
- 1. Special Characteristics Of Pulse Crops That Must Be Recognized For Environmental Sustainability Research 33
- 2. Current State Of Pulse Environment & Sustainability 33
- 3. Foundation Requirements For Environmental Sustainability Research 33
  - 3.1 Long-Term 33

3.2 Holistic 34
3.3 Relevant And Integrated 34
3.4 Strength-Enhancing 34
4. Issues In Environmental Sustainable Production Of Pulses 34
4.1 Greenhouse Gases 35
4.2 Crop Management Issues 36
4.3 Cropping System Management Issues 37
5. Continued Strategy Development Steps 39
Pulse Crop Research Area List **40**

Pulse Research Strategy Background

November 2001

The Reason for a Strategy

The dynamic growth of Canada's pulse industry over the past 15 years has created a profitable and sustainable new sector in crop agriculture. We are leaders in the industry. The growth of the industry is largely attributed to producers addressing market demand. This extraordinary growth of the pulse industry has created anomalies in the research investment profile.

It is now generally recognized that the extremely low level of current investment in research of pulses creates major threats to the future success of the Canadian pulse industry. The three most obvious threats are (1) inability to compete in the long term in view of Canada's low investment relative to competitor regions like Australia and United States, (2) inability to take full advantage of new market opportunities and (3) a potential inability to maintain long-term sustainable production of current pulse crops.

The overall goal of the investment strategy is to ensure that Canada remains or becomes the preferred global source for biological products derived from pulse crops. A fundamental principle in this strategy is to recognize the unique market structure and biology of pulse crops. Pulses are relatively minor crops on a global scale, but are major in terms of supporting global human nutrition. Pulse crops also provide a major impact on the present and future systems and bioeconomics of Canadian crop production, animal production and food processing. Pulse crops are diverse in all aspects – biology, agro-ecology and economy. Each crop has numerous unique market classes, specific zones of adaptation, and particular niches in Canadian farming systems.

Canada – a World Leader in the Pulses

Canada is now the world's largest exporter of peas, lentils and chickpeas and is fourth in beans. Canadians are leaders in pulse crops in the world; in 1999 we supplied 51% of the lentil exports, 40 % of dry pea exports and 11% of beans (The top 20 exporting countries for each crop can be found in Appendix A). Estimates of exports in more recent years show Canadian pulses to be gaining larger shares of the world exports, especially for chickpeas.

Pulse crops are valuable to Canada.

- The value of pulse production has risen to over $1 billion annually (see Appendix B for calculations on the value of pulses and other major crops in Canada).
- The true value of the crop exceeds this when one considers the actual return producers receive from their crops. In recent years producers are finding their pulse crops are some of the few crops that provide a respectable net return to their farms (see Appendix C for the net rate of return of pulse crops and other crops in the Canadian production areas for 2000 –2001).
- The positive effects of pulse crops on the whole cropping rotation are also known to improve the profit margins for the other crops in the rotation. Studies have indicated crops following pulses often achieve an increase of 10 – 15 % in yield plus greater quality due to higher protein content.
- Pulse crops offer diversity to farms, which provides a buffer on the risk of production. The diversity is supplied in the opportunity to grow something other than cereals and oilseeds but also through the expanding number of market classes within pulses.

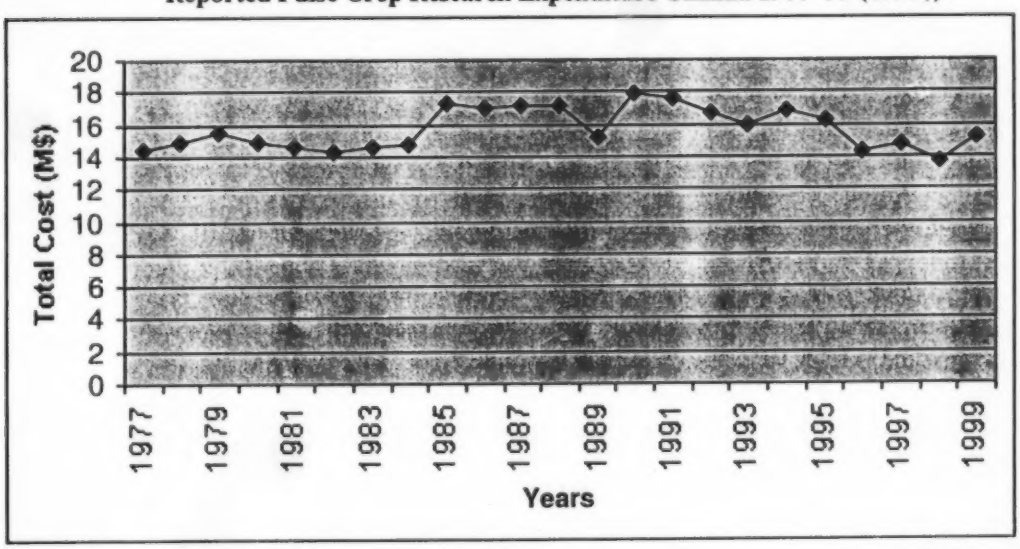
- There are also great benefits to Canadians through the large amount of value added processing that occurs in pulse crops relative to other crops. There is now approximately 1000 pulse processing companies in Canada. Unlike many commodity crops, pulse crops are commonly shipped after a primary process. There is a great deal of opportunity to expand value added activities in pulse crops to secondary and tertiary levels of processing.

Trends in pulse crop industry.

The Canadian Pulse industry is growing fast!! 3000% in the last 20 years

- The funding that goes toward pulse research should not only recognize the value that pulse crops provide for Canada today, but also consider the rapid and large rate of expansion that the industry is facing. At a conservative estimated rate of expansion (27% per year), a program implemented in three years should be 59% larger than a program that would be planned for the current industry and 100% larger for five years in the future. If we were to invest 2% of the crops' value in research, today we should be investing $ 24 million per year, in three years the investment should be $ 38 million per year and in five years $ 48 million per year. Although pulse crop acreage will eventually slow down it is not expected to do so until it reaches 20 to 25 % of the cropped land in Western Canada and that would require another 120 to 178% growth in the industry. These values do not take into consideration the initial need for foundation type spending that has developed due to the shortage of spending that has occurred in the past.
- Historic investment in pulse research has remained steady and thus has not kept up with the expansion of the industry. In order to maintain and further expand the pulse industry this cannot continue.

Reported Pulse Crop Research Expenditure Canada 1977- 99 (1998$)

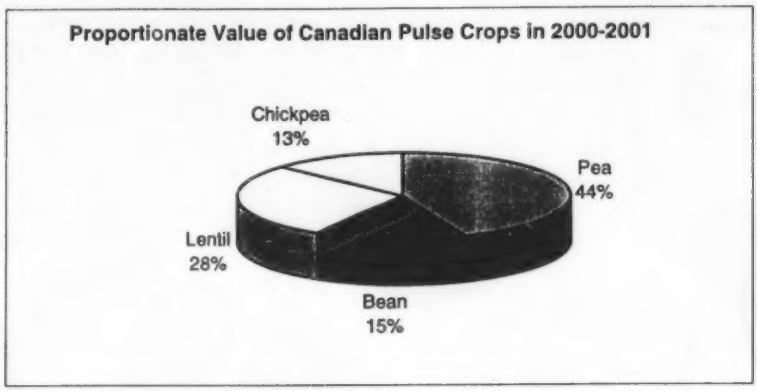


Gray et al., 2000

- The number of market classes is expanding. We currently produce two chickpea classes with different sizes and qualities, five types of peas, six types and sizes of lentils and more than one dozen types of beans. This diversity is likely to continue expanding

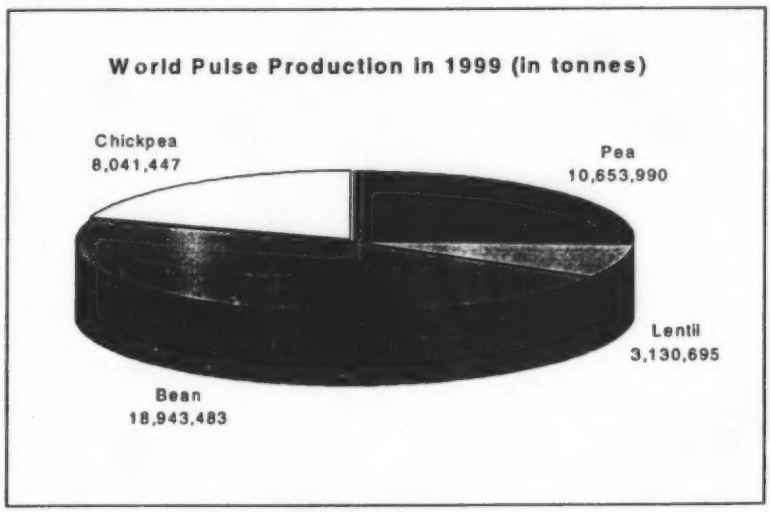
considering that there are over 81 countries trading pulse crops and there is a wide range of requirements and tastes demanded within pulse crops.

- International trade relationships and changing economic patterns have a tremendous influence on the patterns of trade, production and consumption of pulses. It is critical to keep the Canadian pulse industry knowledgeable of world economics and policies.
- Canadian pulses must address the market demand in both the quantity and quality aspects. Currently we know little about the quality of pulse crops that we produce and how the match the needs of the consumer.
- The proportionate value of pulse crops within Canada can be used as a guideline of the amount of spending that should be going to the individual crops.



Future Markets for Pulses

- Future world markets for pulse crops will likely continue to grow because the importing countries of pulses have increasing populations and the major feed importers for peas are turning to vegetative protein sources for animal feed. Appendix D contains the listing of top pulse crop importing and producing countries.
- Beans and chickpeas are important pulse crops globally and yet we are just beginning to focus on addressing the demands in these markets. The markets with expansion capabilities are considered to be chickpeas, peas for feed, specialty classes of dry beans and specialty lentil markets.



The Start

Pulse Canada Research has spent the last few months collecting ideas on the strengths and weaknesses in the Canadian pulse research capability. This document provides an outline of

ideas that have been generated by 53 scientists from varying expertise across Canada (The scientists on the committees can be found in Appendix E). There is not only a strong list of important issues but there are recommended plans of action for research investment in Canada's pulse industry. Four committees in the key research areas of genetic improvement, agronomy, crop utilization and sustainability have developed the following suggestions.

General Ideas Suggested:

The thoughts to date indicate that Canadian research efforts in pulses have many weaknesses. Some major weaknesses appeared. In the case of genetic improvement, programs need to be created or expanded to address new crops and classes, changes in production regions and research in fundamental biotechnologies. In the case of crop quality and utilization research, current efforts are sporadic and minor sidelines in comparison to oilseeds and cereals. In agronomy and environmental sustainability pulse crop research has often taken a back seat to the major institutionalized core research efforts underway for cereal and oilseed crops. Research has been fragmented and incomplete, especially in quality and utilization, sustainable environment and in areas of agronomy and genetic improvement. Research on lentils and chickpeas is hugely under funded for their value to Canada. Sources of long-term funding are required for projects that are longer than 3- 5years in length. There has not been the funding to study pulses at their proportional level of importance to producers and Canadians. The first requirement suggested is to create stability in pulse research by establishing the needed core funded positions.

Pulse Research Requires a Foundation

The majority of funding is soft and delivered through projects. By listing the researchers involved in pulse crops, it became obvious that there are very few core/permanent positions. A number of those positions have ended or will be ending in the next few months and have no sign of new funding. The pulse crop research scientific community operates in a cloud of financial uncertainty and a corresponding lack of ability to attract young scientific talent.

The rapid expansion in the industry has resulted in inadequate infrastructure for chickpeas and lentils and weak research in optimum locations for peas and beans.

Before research issues in pulses can be addressed, we must establish an appropriate foundation of people and infrastructure. Major needs for programs and scientists are listed under the research areas later in this document. Detailed listing of the required core –funded (or A base) personnel required across Canada can be found in Appendix F. Although the list of additional personnel is extensive, many of the needs in pulse crops can be address by current researchers shifting more of their time into pulses. Some new positions are required, especially at the level of technicians.

There is also a need to establish a network of research sites across the various climatic regions in Canada. Appendix G is a map of suggested locations. These locations should be designated as long-term study sites that can be used for studies requiring activity in different climatic regions such as, minor use pesticide registration, sustainable environments, pathology and pre-registration variety development. These sites maximize the use of current infrastructure and professionals that are in place. Appendix H lists a suggested network of places and people that could establish the network. The use of such a network of sites will help to fill gaps in research and to prevent them in the future and remove duplication of research. Most of these locations exist but a commitment of time and space for pulse crops is required. Some funds will have to be

found. Long-term funding for these places and positions are required to sustain a network that will be able to not only address the current needs in research but also be capable of adapting to the rapid changes in the industry.

Interaction and discussion should occur on a regular basis between pulse crop researchers within their discipline and between disciplines. This is essential within Canada but should be expanded internationally as well. Travel funds are required. To improve networking it is recommended to:

- Expand the current pulse workshops to include all research disciplines.
- Create a pulse coordinator position for each of the major research areas, Genetic Improvement, Quality & Utilization, Agronomy and Sustainable Environment. The activities in this position would be to act as a researchers and liaison between researchers within Canada and between Canada and other international researchers for the network projects that require some support in that area

The types of funds available have been dominantly soft and on a project-to-project base. Few core funds are available and few long-term funds. New commitments are required by funders across Canada to establish the permanent positions and infrastructure listed in Appendix D and in the Foundation Requirements sections for each research area. Long-term funds (5-10 year allocations) should be made available for long-term project such as environmental studies, such as the impact of pulses in rotations, and for breeding.

General Foundation Needs requiring funding:	***Estimated Cost***
• Establish a network of eco-region based research sites covering all pulse growing regions in Canada. These sites would support field research for agronomy, environmental and genetic improvement research. Three Level 1 sites (besides the major genetic improvement centres already in existence or expanded as explained above) estimated a 3 x $0.1mill = $0.3 mill/yr; Eight part time Level 1 sites estimated at 8 x $ 0.07mill = 0.56 mill/yr; and fifteen Level 3 sites estimated at 15 x $0.05mill= 0.75 mill/yr.	$ 1.6 million / yr Potentially extra costs for set up if infrastructure is lacking.
• 3 Research Coordinator positions: Genetic Improvement, Quality & Utilization, Agronomy & Sustainable Environment	$ 1 million/ yr
Yearly permanent investment required for general foundation	**$ 2.6 million/ yr**

Note that more foundation requirements are listed under the individual research area strategy ideas.

Ideas for Research Areas

The following sections outline the ideas developed by each of the research strategy committees. Although the producer and market needs were considered, the ideas are dominantly from the research perspective. The whole industry will have a chance to discuss and develop the strategy at the workshop. It will also be important to develop some thoughts on how we can all work together to implement the strategy and to establish a plan on what further planning is required.

Quality & Utilization Strategy Suggestions

1. SPECIAL CHARACTERISTICS OF PULSE CROPS THAT MUST BE RECOGNIZED FOR QUALITY AND UTILIZATION RESEARCH:

- There are a large number of pulse crops and market classes in Canada and around the world.
- The uses and quality preferences within each crop are wide ranging.
- It is recognized that pulses contain some unique starch, protein and fiber characteristics.

2. CURRENT STATE OF QUALITY & UTILIZATION PULSE RESEARCH:

- The basic quality characteristics of pulses produced in Canada are still largely unknown.
- Customers of our pulses are starting to place more value on quality attributes.
- The feed industry is gaining the information needed to use peas effectively as a regular component in feed mixes.
- Only a few researchers in Canada have studied pulse utilization for food and industry uses. In many cases pulse research has been only a low importance side project.
- Canadian researchers are still learning what each other do and the way pulses are used around the world.

3. FOUNDATION REQUIREMENTS FOR QUALITY AND UTILIZATION RESEARCH:

- Establish networks to address the research so the pulse industry can capitalize on the expertise across Canada. A list of research facilities can be found at the end of Appendix H.
- Develop a Canadian compositional and quality database
- Establish Canadian standard methodology for measuring quality characteristics of pulses
- Develop a research database to establish an understanding of research that is being performed on the quality and use of pulses around the world (i.e. functional foods, nutraceuticals, starches and proteins for food, feed and industrial uses.) Initial steps have been taken to start the database. It was found that there are about 9347 papers in this area from the years 1990 – 2001. From the 3 most recent years, there are 1266 papers that have been categorized, many of which contain research that can be used as a basis and provide some guidance to future research. There are many papers that are gems dispersed amongst a large number of papers of variable quality. It is important that we find the gems.
- The committee recommends the following:
  1. Run a patent search on processes and products for pulses.
  2. Categorize all remaining scientific papers (1990-1998) and the patents to develop a complete database.
  3. Maintain the database and make the information accessible by placing it on the web. The target audience is researchers.

Market intelligence is required to provide some focus and direction in future research and needs to be established in the following areas:

1. Provide a summary of Canadian pulse crop values, volumes and uses both domestically and for export. Much of the information has been derived for exports but needs to be developed for domestic use. The split between feed and food use should be added as well.
2. The information on uses of the crop need to be expanded from the primary level to final use – i.e. boiled into soups or stews, canned, milled to flour and then used as…, used as feed for what type of animals, etc. Then information should be collected on what quality traits are important for that use – i.e. how quick should it cook, what texture is preferred, etc.
3. For further direction the information listed in #1 and #2 should be broken down into the different classes of the crops.
4. Chickpea flour use and milling practices. What is the flour used for around the world? What characteristics are preferred and required?

5. It is suggested to obtain some of the end use information by speaking with ethnic groups w/in Canada instead of traveling.
6. Intelligence on what the other pulse exporting and producing countries are doing for quality and utilization.

The following funding is required for foundation work in quality and utilization research:

Yearly compositional and component measurements of crop to provide information for market, food safety and value added (food, feed & industrial) uses.	$ 0.5 million/ yr
Methodology, quality assessment of Canadian crops and value-added (food, feed & industrial) studies. • Pilot project for the component database on pulse crops in the next year. Leader of the project is Ning Wang. 1 yr, $150,000 • Carbohydrate Component Methodology – suggested leader -Marta Isadorczyk 1 yr, $100,000 • Basic physical description, uniformity, definition and measurement of pulses Leader Steve Symons CGC 1 years , $100,000 • Standard canning methodology - Leader Soon Park, 1 year, $50,000 • Cooking Quality, Methodology And Database For Pulses - network: Alberta, Ning Wang, Sue Arntfield, UofM, Gene Arganosa. (Guelph ?) Rick Yadda? Alex Merengonie??? 4years, $800,000 • Milling Quality Of Desi Chickpea, Start Up Project. Leader - Linda Malcomson 5 years, $300,000 • Run a patent search for processes and products for pulses. Categorize all remaining scientific papers (1990-1998) and the patents to develop a complete database. 1 yr $30,000 • A Lit Review on the health benefits of pulses 1yr $50,000 • A Lit Review on pulse starches 1yr $50,000 • Maintenance of the database on an annual basis. Ongoing $25,000/yr	$ 1.7 million
Capital requirements to establish/expand quality & value added research.	$ 3.0 million
One time investment	**$ 4.7 million**
Yearly investment that will be ongoing	**0.5 million/ yr**
Total	**$ 5.2 million**

This total is small because the people and infrastructure that have the research ability already exist. The largest area of need is an influx of project funds in the areas of research listed (see section 5.). This would allow the balance of research to shift to the appropriate level of work on pulses.

4. ISSUES IN QUALITY AND UTILIZATION RESEARCH

4.1 Quality

- Establish a Canadian compositional database. This information is critical for developing a complete utilization strategy as well as for background information required for marketing. The Canadian pulse quality initiative has set out some guidelines of which measurement should be done. Progress has been slow due to the lack of funds.
- Establish standard methodology for measuring the different quality attributes of Canadian pulses. This activity will work in conjunction with the development of the international quality testing methodologies.
- Once the measurements of composition are underway we need to start activities that advance us to the proactive approach.

Components

- Thoughts:
  1. We do-not want to duplicate the work that the Australians have already done but we need to determine how our information compares to theirs and the rest of the world.
  2. The change in crops during storage, especially in the first few weeks after harvest but up to 6 months or a year would be an interesting project for the future.
  3. Samples should be managed and processed in a consistent manner (all prepared in the same manner0 and the work performed in as centralized of a location as possible. The CGC is taking on this role.
  4. We need to determine which components measurements are new and old for use in funding applications. Many of the measurements are new but some like protein have been dabbled in for years.

Status of the current pilot project on pulse component analysis at CGC:

- Pea & lentil (+soybeans) samples from the 1999 harvest -chose two samples based on the largest differences in protein levels in each crop – 4 pea samples, two yellow pea samples and two green pea samples - 4 classes of lentils. Would like to add a second year. This research needs to be completed by next June. Methodology used is close enough to the Australians that you could consider it the same.
- Discussions on what more is needed from the pilot project:
  1. Add the measurement of non-starch polysaccharides, soluble and non-soluble starches.
  2. Expand the study, as intended, to chickpeas and bean.
  3. Need the Amino Acid balance –144 samples
  4. Need the vitamin levels analyzed –144 samples
  5. Run a second year on the peas and lentils.
  6. Run two years 2000, 2001 for chickpeas, 2 kabuli and 2 desi
  7. Determine what data has already been collected on beans before determining what maybe required.
  8. CGC performs all analysis except the vitamins and AA profile.
  9. CGC will put out a call for quotes for the AA and vitamin analysis. Suggested labs to contact are: AAFRD –Hong & Connie, MB Food Development Centre, Guelph, etc. Approach provincial and university labs. The vitamin analysis is estimated at $500/sample x 150 samples =75,000, AA are $200/sample x 150 = 30,000. Contracted analysis ~$115,000.
  10. The CGC will need to contract one additional technician on staff for one year to achieve these analyses in one year. This is assuming that the current 2 full time technician positions are maintained. Funding would have to be provided for January and February for the one technician until CGC creates the second full time technician position dedicated to pulses in their new calendar year. The cost for these technicians would be $35,000.
  11. Run component analysis on an American soybean meal standard and possibly a canola meal as a control.
  12. Samples should be kept after component analysis for potential digestibility trials. Trials with nylon bags would only require about 1 kg of sample.
  13. Final chemical component analysis list:

      Proximate analysis is the highest priority:

      Protein (N) + amino acid profile

      Carbohydrates – free sugars,

      Soluble and non-soluble starch

      Fiber (ADF, NDF, Non-starch Polysaccharides)

      Lipids (crude fat)

      Ash

      Minerals (Na, K, Cu, Fe, Mn, Mg, Zn, Co, Se, S, P, Ca) –mineral scan covers all but S which need to be measured.

Vitamins and Pronutrients: measure the full vitamin analysis for labeling
B complex
Vitamin A/caratene
Vitamin C
Vitamin E
Vitamin K,
Folic acid
Choline
Antinutritional Factors
T1A
Phytate
Oligosaccarides
Saponins,
Tannins (total and condensed)
Cyanogens- only for beans
CTIA, Lectins, and Alkaloids dropped - can be added later if a need arises.
Other: Fatty acid composition of the lipids
Pigments (Carotenoids, chlorophyll based, phenolic based)
Lipoxygenase (enzyme involved in flavors)
Amylose/amylopectin ratio
Phytoestrogens – AB Food centres working on this
Other measurements of quality just to round out the study:
Physical Characteristics:
Size, seed weight (100^{th}'s) should be using mg. Color: Only on whole seed color.
Consider:
Cooking Quality:
Pigments: Quality issue, even on feed side. Don't forget aquaculture.
Bitter Flavors

Project:
Finish the pilot project for the component database on pulse crops in the next year. Leader of the project is Ning Wang. Costs $150,000. Time: 1 yr. (Listed in the foundation work table)

- Next steps for components:
  1. Find what component information there is on Canadian beans and determine what needs to be done.
  2. Compare results of the pilot study against the Australian database to determine any inconsistencies. Set out the next database studies that are needed.
  3. The difference between varieties is of interest, especially in peas for feed. The Alberta study will address these questions for now. The need for varietal studies will be reviewed after receiving the pilot results. Performing component analysis on all varieties would be a huge and expensive task that may outdate quickly.
  4. The target is to develop the database on each pulse crop and add information for each new variety as they are developed. (The coop testing is not extensive enough for the database.)
  5. Start developing NIR methods for component analysis (especially important in the feed industry).
  6. Research how the amino acids are being calculated from the crude protein. Determine whether the prediction equations apply to our pulse crops. Look at how the equations were derived, number of samples as basis, where the samples came from etc.

Quality methodology
International Pulse Quality Committee (IPQC) has started addressing the methodology needs. It is best to work at the international and national levels to develop the methods we need.

International methodology research:
The methods being developed need to be internationally accredited. It has been agreed that this is best done through the American Analytical Cereal Chemists (AACC). AACC has agreed to establish a pulse subchapter and will hold a pulse method symposium in the fall of 2002 in Montreal to start the process.

Methodology research by the International Pulse Quality Committee.

Parameter (in priority order)	*Method*	*Leader*	*Status*	Estimated Funding Needed [1] ($US)	*Time Required*
Size	Standardize Sieving Method Correlate Image A	Steve Symons	Sieves – need survey & standard Co-Develop Instrumental Methods	$30,000	6-8 mnth/ comm & ring test
Moisture	Gray metric AACC 44-15	Jim Daun	Published method needs minor Modification and a ring test	$10, 000	1 yr to 2 yr
Impurities	ISO 605 or CGC	Jim Daun	Move current method into an AACC	$12, 000	> 2yrs
Water Absorption	Hydration Capacity –	Jim Panozzo	Validate method for inclusion to AACC - see above	$14,000	1 yr
Cooking Quality & Time	APQ as a base	Ning Wang	Review methods, Explore collaborations, Define project, Build from APQ	$10,000	1 yr
Split yield & Dehulling Efficiency	APQ	Joe Panozza	Develop Method/Equip Crop Specific – Add Lentils	$12,000	1-1 ½ yr
Seed coat integrity	Visual assessment Michigan Protocol and Industrial Protocol	Gene Argonosa	Evaluate\agreement on Protocol	$10,000	1 yr
Canning Quality	Future				
Protein	Dumas in AACC\ISO	Jim Daun	Ring tests under design (method established)	$4000	1 yr to 18 mos
Fibre	AACC Methods NIR	Byungke e Baik	Proposal to validate for Pulses Future Development of NIR	$30,000	1 yr ?
Starch	AACC as Base	Joe Panozzo	Review Developed Methods Assays to choose & develop NIR future	$25,000	1 yr
Vicine/Convicine	HPLC	Gerard Duc	Is in progress in Europe Method development work	$30,000	1 yr

Trypsin Inhibitor	AOCS method AACC method ISO Method	D. Page	Is in progress in Europe Method Development work	$25,000	2 yr
Tannins	Future				
Total				$160,000	

[1] The actual external funding needed for each project may vary according to the participant's ability to provide internal assistance. For example, project costs at GRL refer to external funding needed only. Internal funding for these projects would at least equal the external amount needed.

Status of the methods being addressed through IPQC:

- Color & size- Steve Symons – CGC -working on a better method for color but is a complex area. The size measurements are just getting started. Need to determine the type of sieves being used, what is available and how they are being used. Funding into the area would expedite the work because there would then be someone available to do it.
- Moisture –Nothing has been done yet. Need funds to hire a technician to do the work.
- Impurities – future work
- Water absorption – method is nearly complete. The next step would be a ring test through AACC to get accreditation.
- Cooking Quality and time - Basic work has been started. Methods from around the world are being compared. Will not get done in a year without funding for additional help.
- Split yield and dehulling – Joe Panozzo is working on this. AAFRD is interesting in joining in on this study.
- Seed Coat integrity – unknown status
- Protein – have the method. There is an agreement from ISO to proceed. Ring test being put together on this years harvest. No funding needed.
- Fiber – unknown status. Will fall under AACC. Question on whether TDF based method should be chosen as the base method before moving to NIR.
- Starch, Vicine/covicine and trypsin inhibiter work is ongoing.

The AACC pulse subcommittee will have volunteers. Possibly Ning Wang, Joe Panozzo, Kevin McPhee, Gene Arganosa would like to be committee member. Linda Malcolmson would like to be an associate member.

Method research required nationally:

- Color - different manufacturers have different results. Each manufacturer adds different formulas to the original measurements. None of the machines are wrong, but none agree. Color is very nebulous. The imaging methodology being studied, variability of color is being considered to decrease the inconsistencies.
- Different commodities have different color issues.

Project: color description, uniformity, definition and measurement $500,000/5 years. Steve Symons leads $100,000 per year for 5 years.

- Carbohydrate component methodology is unresolved and yet carbohydrate analysis is so important for the feed, food and industrial uses. The study will build on past methodology.

Project: Carbohydrate component methodology Suggested leader Marta Isadorczk working with AAFRD. 1 year, $100,000

- Canning – a collaboration has been suggested at the national level in the past by Soon Park. The bean breeders across Canada would like to standardize the test – Harrow, CDC Saskatoon, Lethbridge and Leduc are interested.

- Dehulling and splitting is of interest in Canada – Ning and Gene have worked some in the areas, AAFRD is also interested. They will talk to Joe Ponozzo in Australia to see what needs to be done.

- Cooking methods are important since it is the end use of a number of the pulses.

Project: Cooking Quality, Methodology And Database For Pulses - Network: Ning Wang, AFFRD, SueArntfield , UofM, Gene Arganosa. Someone in Ontario (Guelph ?) Rick Yadda? Alex Merengonie??? 4 YEARS at $200,000 year = $800,000.

- Milling is a completely unknown area. Some market analysis needs to be done to find out what methodologies are required. We need to know what's being done and the uses of chickpea flour. First year spent figuring out what needs to be done. Small-scale assessment.

Project: Milling Quality Of Desi Chickpea, Start Up Project. Linda Malcomson, 5 years, totaling $300,000

4.2 Utilization

Initial baseline research is required to establish value added uses of pulses. The most critical information required is the basic component research, which has already been discussed. It is also important to conduct research on new and expanded uses of pulse crops in food, feed and industrial applications.

Animal feed Uses:

- The objectives listed are in the order of importance. Note that the focus is on peas because the other major pulses are only used for feed when their quality does not meet the food market and therefore are severely discounted in price.
  1. Compositional database
     - Evaluation of the critical components for animal nutrition according to standards set domestically and by importing countries
  2. Reduce foreign material content guidelines from 8% to 1%. This is more of a policy issue but is one that is critical to the feeding industry. The increased FM can be made up of GMO material, that will not be tolerated by Europe, our major pea export customer. We would lose the majority of our market over this issue. Even domestic animal production units will not tolerate a blend of 8% unknown in a major ingredient. The feeding rations are calculated precisely. The only way this high of FM is tolerated is through large discounts in price and even then top production units will remain uninterested.
  3. Breed a pea specifically for feed use – ie. The best one for pigs. The goal should be to maximize digestible energy (or net energy) per acre.
  4. Varietal assessment -The above will allow for extremes to be discovered and will assist in the establishment of differences between major varieties of green and yellow dry peas.
  5. Effects of Processing
     - Particle size: Optimum mean particle size and distribution for pigs and poultry.
     - Heat treatment: Comparison of raw versus heat-treated (eg. pelleted, micronized, extruded) on feed intake in pigs. This comparison should be done with all the major varieties.
- The feed industry could use a high protein supplement but one would not be economical to produce from peas unless a use for the starch can be established.

The areas of research required are:

Project: Evaluating Feeding value of pea

- Establish the differences between green & yellows,
- Study the rates of digestion of different pea starches –determine what makes pea starch slower to digest and provide the knowledge so the breeding program can avoid poorer quality starches.

- Determine the factors affecting energy
- Determine the factors affecting feed intake. Tannins & digestion rates
- Level of digestible nutrients

Leader - Leigh Campbell, suggested network: William Sauer, Ruurd Zilstra, Martin Nyachoty, Phil Thacker. 5 years $1 million total.

Project: Effect of Processing on feed

- Grinding efficiency
- Pelleting efficiency and durability
- Energy costs of processing,
- Literature search on: (Background for research and marketing)
    - Methods for processing - dehulling/splitting, air classification.
    - Methods & equipment for developing pea protein isolate and protein concentrates

Suggested Leader - Ian McCullum, Suggested network: Barb Stefanyshyn-Cote, Jim Gowans, Darrell Lishinski, Joe Hancock, Connie Phillips, and Bob Tyler. 1 year $100,000 total.

Food Uses:

If we want to diversify the use of pulses, it is suggested to start looking at special whole grain uses and also to move to further research into the uses of components.

Discussion :

- Marketing intelligence is needed to determine where we have a competitive advantage.
- Start by looking at whole and dehulled pulses as ingredients and as functional foods.
- Research needs to be done to demonstrate some of the benefits of eating pulses. We need to find out what pulses are capable of in regard to health benefits, for example pulse consumption reduces cholesterol, etc. There is significant knowledge to be gained so that we can stop alluding to facts and state them.
- Marketing can start promoting pulses from the health aspects, a pristine environment, healthy product. This could be a problem if we promote that they're great when there's not much to buy.
- Need to develop and market pulse-based foods that people want (taste, look, etc) that are functional foods.
- Initiate research that can help companies produce ready-made pulse products.
    - Product development area; develop a process. Rationalize and justify that this is practical and marketable to people. Potential markets could be people with food allergies, geriatric markets with meat-reduced diets (lentils will work here), vegetarian foods, gluten free diets, etc. You have to be able to show a product to a company in the form that they would be selling it and back it up with consumer verification that it would be eaten. Development of applications and approaching the right companies.
    - No known activity in the private sector in this area so scientists' wouldn't be overlapping or interfering with the private sector.
- Part of the problem is that North Americans just traditionally don't like pulses because they are a bother, some don't like the taste, and the flatulence effect. Thermal processing alleviates a lot of the flatulence.
- Consumers need something that looks good, tastes good, is ready to eat in ½ hour, and then they will buy it.
- We need to get the products on the shelves with pulse ingredients in them.
- Need to provide consumer education on the benefits of eating pulses. :Soy is a good guide – how well they have marketed their product.
- The prototypes to start with should be based on the crops functionality and form.
    - Snack foods are obvious because it is a huge market here
    - Breakfast cereals

  - Pasta noodles -High protein, high fiber, nonallergenic and suits a wide range of tastes.
  - Texturized vegetables
- Research would be needed to get pulses into the form where they are an ingredient. Extrusion & micronization work
- We need to find out what pulses are capable of. Does pea protein do what soy does?
- The most important thing to work on is starch utilization

Project: A Lit Review On Starch Utilization - $50,000

Project: Pulse Starch Utilization – Leader - Thava Vasanthan Suggested network with new starch specialist at the U of M and R. Hoover from Memorial University of Newfoundland 5 years 500,000

Project: Pulse Flour Utilizaton – Leader - Connie Phillips, AAFRD, Network of Sue Arntfield, Bob Tyler and check to see if there is someone in Ontario or other parts of Canada. Linda Malcolmson for food side. Industrial uses, blends, food aid, extrusion, baked goods, specialty niche markets(gluten free, etc), cereals, any reasonable substitute for a wheat based product. 5 years $ 500,000

Project: Whole Seed Utilization – Leader - Sue Arntfield, U of M, Network of Connie Phillips, Bob Tyler and check to see if there is someone in Ontario or other parts of Canada. Linda Malcolmson for food side. Using the whole seed roasted, micronized, etc. 5 years $500,000

- The current funding structure from most of the funding agencies requires industry money as well as the contributor. As a result the knowledge gained becomes confidential and not open to the industry. Much of the research suggested needs to remain as public knowledge that all Canadians can build on. This problem must be addressed from the start.

Health benefits and nutraceuticals

- Essential information to elevate the status of pulses in the North American or European markets. We have an edge with pulses in Europe because they are non GMO. If we want to position pulses in the market place, we have to invest money into it.
- First find out what has been done on unidentified nutraceuticals. There really isn't any Canadian Data. A search on the database/lit review would produce information that has been developed around the world. The bit of database development that has been done shows that there has been substantial research in this area that we can use.
- Information on the markets for nutraceuticals is available in some studies done for 2000, 2001 by AAFRD.
- Do the search and match it up with AB Ag nutraceutical market information. Then we'll have target areas to go after

Project: A Lit Review On The Health Benefits Of Pulses $50,000

Project: Research Looking For And Evaluating Neutraceutical Type Components. Start with a screening of our Canadian pulses for the levels of nutraceutical components. Some areas of interest maybe Biofavonoids, glycemic index, Saponins, oliosaccharides, etc. Leader Kelley Fitzpatrick Network to be established – dependent on the direction provided by the literature review. 5 years $1 million.

Industrial Uses:

- There needs to be a study of what the starch and protein markets are looking for in components. The pulses will then have to be screened for those specific components and determine their

application specific criteria. This information could be used for targeting breeding of specific pulses.

- The protein uses are limited by the lack of starch uses. Uses need to be found for the byproducts.
- The starch utilization study will work on industrial uses.
- Peas show some unique binding characteristics that we haven't tried exploiting. There is a need to find out what the starch buyers are looking for.
- All of the pea starch used in Canada is used in non food – briquettes, etc.
- Potential opportunities could be:
    - Paper
    - Pre gelled
    - Existing markets?

5. IMPORTANT RESEARCH AREAS FOR QUALITY AND UTILIZATION

The research areas recommended by the quality and utilization committee are studies involving large networks running multi- projects that will address the issues.

Pulse Starch Utilization – Lead by Thava Vasanthan,

Pulse Flour Utilization (blends, food aid, extrusion, baked goods, specialty niche markets (gluten free, etc), cereals, any reasonable substitute for a wheat based product.)

Whole Seed processing – micronization, roasted, etc. (snack foods, cereals)

Studies Looking For And To Evaluate Nutraceutical Type Components -Lead by Kelley Fitzpatick

Evaluating Feeding value of pea -differences between green & yellows, starch rates of digestion, factors affecting energy, factors affecting feed intake. Leader Leigh Campbell suggset network, William Sauer, Ruurd Zilstra, Martin Nyachoty, Phil Thacker

Effect of Processing on feed - Grinding efficiency, pelleting efficiency, energy costs of processing, lit search on methods for processing - dehulling/splitting, air classification, and methods for pea protein isolate and protein concentrates Suggested Leader Ian McCullum
Color description, uniformity, definition and measurement Leader Steve Symons CGC

6. CONTINUES STRATEGY DEVELOPMENT STEPS:

- Develop further research plans on components once the pilot study is done in 1 year.
    - Focus on areas where there are differences between values within Canada
    - Focus on areas that appear unique for Canada

Genetic Improvement Research Strategy Suggestions

1. SPECIAL CHARACTERISTICS OF PULSES CROPS THAT MUST BE RECOGNIZED FOR GENETIC IMPROVEMENT

- There is a wide range of pulse crops and market classes that fit into many climatic regions of Canada. Genetic improvement needs to be targeted at all of these crops and regions.
- Many pulses are susceptible to diseases (to the point of limited production in many areas in the world) and are poor plant competitors (resulting in weed problems).
- Consumers express a wide range of preferences and tastes for each of the crops and in some cases even within a crop class. The large number of quality parameters demanded must be known and addressed.

2. CURRENT STATE OF GENETIC IMPROVEMENT RESEARCH IN PULSES:

Crop	% of Canadian pulse crop value	Number of breeders Person Years	Number in biotech Person Years
Field pea	44	2.25	3 (1 temporary)
Lentil	28	0.5	1
Chickpea	13	0.5	0.5
Field bean	15	5	2.5
Other pulse crops	-	0.1	0
Totals	100	8.35	7

Peas:

- Pea breeding is carried out by one person in Morden, one half of a person's time in CDC, Saskatoon, smaller amounts in CDC - North, Edmonton and in private companies.
- The major pea production area is in Saskatchewan (70%) followed by Alberta (25%).
- Presently the focus is to select lines that have dual-purpose properties in food and feed end uses. High yield is the primary concern during selection. Disease resistance has been found for powdery mildew but is largely unachieved for Mycosphaerella and root rot (difficult to achieve plant resistance). Quality improvement has been addressed to a minor extent.
- Only small amounts of work have been done in developing tissue culture systems, di-haploidy and molecular markers. Transformation has been achieved but the technology needs to be improved.

Lentils:

- Lentils from Canada continue to dominate world trade.
- World trade involves many classes of lentils. In Canada, the number of classes being produced and the diversity of where they are being grown are expanding.
- Genetic improvement has succeeded in developing lines that survive in our growing conditions and have some disease resistance. The current work is strengthening disease resistance and is just starting to consider selection for quality.
- Work has just begun in developing tissue culture systems and molecular markers. Transformation has been achieved but the technology needs to be improved.

Chickpeas:

- Genetic improvement has succeeded in finding lines that survive in our growing conditions. The current work has started looking at disease resistance (ascochyta) and has not yet been able to consider selection for quality.
- Appropriate seed size, shape, and colour are important for all pulse crops used for food. There is a wide range of characteristics demanded by the market place for chickpeas.
- Very little biotechnology research has been done on this crop in Canada. Double Haploidy and molecular markers have been initiated.

Dry Beans:

- Beans are growing in acreage, expanding in the number of classes being produced and diversifying in the regions of production.
- Bean production has increasing rapidly in Manitoba and increasing slowly in Alberta and Saskatchewan. In Ontario, navy bean production has recently decreased but colored bean production has increased where diverse market classes and new alternative classes are evaluated.
- Genetic improvement specialists and pathologists are addressing many of the key disease issues, especially in Ontario. A program is in place to find important markers for a few major qualitative (i.e. disease) genes in beans. Some markers have been found in recent years and are now being used in the breeding programs. There has been no di-haploidy development or transformation research.

3. FOUNDATION REQUIREMENTS FOR GENETIC IMPROVEMENT RESEARCH

- It is essential to source market intelligence to determine what types of pulses are required for the future and the quality characteristics that the customers of our products are seeding.
- The current testing network to screen potential new lines for each crop is weak, especially in Western Canada. Testing new lines before registration in different ecozones is essential for breeding programs. The program needs to consist of test sites across all ecozones of potential production be maintained by quality staff and provide access for use by all of the pulse breeders (private and public).
- The breeders feel there is a great advantage to establishing collaborated disease screening sites where everyone's material can be tested for resistance to diseases. These sites require pulse pathologists to do the work.
    - There is a need to establish a system for developing new pulse crops and classes for Canada. The breeders require knowledge of market opportunities and support from the industry to develop these high risk but industry expanding crops (look how chickpeas turned out).
        - Pulse Canada must keep the industry informed of new developments so that everyone from producer to agronomist to trader are in position to take advantage of the new crops or classes.
        - Provide on going funding for a collaborative program to develop new pulse crops (new lines or crops in Canada for world markets as well as new lines for specific end uses).
        - Allocate quality and pathology support.

Peas:

- Establish pea genetic improvement programs targeted at developing varieties adapted for the dark brown and gray, thin black and black regions– the dominant production areas.
    - Establish a Pea Genetic Improvement Program for the black, gray and Peace River regions:
        - determine the location within Alberta - ensure adequate lab space, greenhouse space, land, field & lab equipment.
        - hire a pea breeder

  - hire a plant pathologist
  - hire a food scientist to allow a quality focus in breeding
- Expand the current Brown and Dark Brown Ecoregion Pea breeding program (located at CDC, Saskatoon) from a half time breeder into a full time breeder position.
- The current small amount of pea breeding activity limits activities to basic yellow and green varieties. If the industry requires more specialized products, there will have to be more support.
- A collaborative effort must be developed for screening new breeding materials in all growing regions before registration. One of the largest limitations to varietal development in peas is the lack of ability to test new materials in different agro-climatic zones to see where they perform well.

Lentils:

- There is a need for lentil nurseries at reliable locations. The only lentil breeding program in Canada does not have consistent funds allocated to test the new lines in the lentil growing region.
- Infrastructure for field-based technical work for breeding and for all the associated research activity is in extremely poor condition. The field laboratory facilities in Saskatoon may in fact fall far below occupational health and safety standards.
- Establish a permanent position for a full-time lentil breeder and provide critical technical support staff.
- Greenhouse and growth room facilities pose a constraint for lentil breeding. The biology of the plant dictates that lentil, like all the pulses, occupies a much greater horizontal area compared to cereals and flax. Facilities are rented depending on availability of funds and facility space.
- One of the most obvious deficiencies is the lack of a full time pathologist dedicated to lentil breeding efforts. The Canadian lentil crop and the US bean crop are almost equal in size and value, yet all 6 breeding programs in the US have at least one resident plant pathologist. Pathologists in Canada are leaving the pulse research field because of lack of core funding and poor support. Many aspects of our disease screening systems need to be improved.
- Provide funding for interaction and exchange of materials with other breeding centres around the world (critical when there is only one breeding centre in Canada for the crop). Good strides can be made with germplasm development by dedicating resources to harvesting genes for useful traits from wild germplasm in lentil. This work needs supplementation of personnel and physical resources through an integrated biotechnology approach that involves tissue culture, doubled haploids and genetic mapping.
- Once quality standards are in place, there will be a requirement for some investment to ensure that breeding materials are selected within appropriate quality limits.

Chickpeas:

- The lab facilities In Saskatoon for field research are inadequate.
- Testing sites are a necessity. Advancement can improve substantially by adding one testing site besides Saskatoon possibly in Brooks, AB or Swift Current SK. For more advanced lines (closer to registration) several testing sites are required. Even the regional testing is limited (especially in Saskatchewan) and is unpredictable due to variable funding.
- Establish a permanent position for a full-time chickpea breeder and provide critical technical support staff.
- There is a need to collect international germplasm with desirable traits (improved ascochyta resistance), early flowering/early maturity, large seed size kabuli) to develop improved varieties.
- Increase plant pathology support to a full time plant pathologist for chickpeas.
- There is a need to expand tests for quality. I.E. canning and desi lines should all be tested for splitting ability and flour yield.

Beans:

- Manitoba requires a larger bean breeding program with more financial commitment to support the increased production in that province.
- Ontario needs to maintain its breeding activity and as a minimum sustain one public breeding centre.
- The focus in Ontario breeding will shift to premium priced, specialty beans. Ontario can grow the beans that demand longer seasons and diverse market types and have identity preserved production and marketing systems to support them.
- Changes to the breeding institutions should be done over a 2 to 3 year time frame with replacements hired in advance to learn from retiring personnel.
- The system and infrastructure must adapt to changes in the industry over time, considering both production and market needs and the activity of private breeding
- The west side of Manitoba and east side of Saskatchewan needs to develop high quality screening sites for beans.
- A universal quality assessment system needs to be developed across Canada to determine the regions capable of producing the quality levels demanded by the market. We also need to consider quality characteristics of emerging and future market classes.

Biotechnology

- Develop and expand the current biotechnology programs. Peas, lentils, beans and chickpeas $150,000/year per crop for 5 years for marker –assisted selection and $150,000/year per crop for 5 years for tissue culture plus equipment.
    - Lentil & chickpea molecular markers, pea & chickpea double haploidy work are being done at CDC, U of S.
    - Lentil double haploidy work is done at PBI.
    - There is no sustained pea marker work being done. Some is being performed at Morden, the Cereal Research Center and Swift Current.
    - Beans have a current program for marker-assisted selection that occurs at Guelph and Harrow. There is potential at Morden.
    - Guelph is interested in the tissue culture aspect as well.

Foundation requirements	*Estimated Cost*
• Develop and implement a complete plan for the Alberta Pea Genetic Improvement Program and commit to the time lines and funds required. • Expand the Saskatoon pea genetic program to a full time breeder and technician.	$ 0.7 million /yr $ 2.0 million setup $ 0.2 million/yr
• Develop and implement a complete plan that will build one full genetic improvement program for each of lentil and chickpea in Saskatoon CDC : - build a new field lab, equipment, land. - a full time breeder for each crop (2 senior scientists + 2 senior technicians), committed long- term funding for yearly greenhouse, growth chamber, field screening costs and baseline quality measurements.	 $ 10 million $ 1.3 million/ yr
• Increase the annual funding in the Morden Bean Genetic Improvement Program. - Bean breeder and technician - Capital costs for plot and lab equipment	 $ 0.4 million/ yr $ 0.4 million
• New pulse crop development programs.	$ 0.5 million/ yr
• Develop and expand the biotech program. - Capital costs for equipment	$ 2.0 million / yr $ 0.7 million
• Baseline quality measurements for potential crop lines and utilization (food,	$ 0.5 million/ yr

feed & industrial) research.	
One time investment	**$ 13.1 million**
Yearly investment that will be ongoing	**5.6 million/ yr**
Total	**$ 18.7 million**

4. OBJECTIVES FOR GENETIC IMPROVEMENT

Peas:

- Pea breeding will focus on feed peas and food peas in yellow and green types. The pea breeders felt that they would be capable of targeting the two uses in each of their breeding programs. The split of time and resources between the food & feed pea breeding will be based on the market share of each in both volume and dollar value. Peas have become a feed of choice. It is important maintain a supply to meet the demand and enhance the quality of peas used regularly in feed rations.
- The following breeding objectives will be used to prioritize research
  - The top three input objectives are yield, disease resistance and plant architecture.
  - The next breeding objectives for feed peas are high protein, high energy and low fiber. This area will become more important in the long-term (> 5 years) after there is better methodology for assessing the energy value of the feed. The anti-nutritional components are in a maintenance mode. More quality information is needed before breeding can maximize amino acid profiles.
  - For human consumption, pea breeding needs to focus on bleaching tolerance for green pea followed by seed uniformity, hedonic (taste & texture) and fractionation/processing traits. It was felt that intrinsic characteristics (cooking & splitting) were important but likely rated low because they are difficult to measure at this time.
- Breeding activity in niche markets will be based on the value of those markets. Interesting & unusual by-products from breeding mainline products will be used as a good source of material for the lower importance niche markets.
- It is recommended to maintain more than one crossing location to reduce the risk of losing all material in the case of a disaster and to maintain at least two differing views during selection of materials.

Lentils:

- Work towards ideally adapted lentil lines with improved stem stiffness. Such work would likely result in a reduction in levels of most foliar diseases, and a corresponding increase in seed quality and yield might occur.
- Breeding will target the main objectives of increasing yield, ascochyta resistance, anthracnose resistance, improving seed quality (colour and shape), decreasing lodging through increasing stem strength and optimizing maturity. By market class, emphasis will be on large green = red > medium green = small green > French green = Spanish brown > zero tannin. The two largest classes, large green and red, probably represent 60-65% of the program right now. This roughly corresponds to market share.
- Botrytis, Sclerotinia, and Stemphyllium are the next set of foliar pathogens that may increase in severity in response to better genetic control of Ascochyta and Anthracnose.
- Implement a procedure to systematically explore the combining ability of germplasm from Australia (which really is ICARDA germplasm until recently), ICARDA, the USA, and more recently Ukraine, Russia and Tanbey. In the medium term, there will be attempts to exploit the variability of wild lentil species, not directly as parents, but as useful contributors of genetic variability and of resistance to biotic and abiotic stresses.

- Plan the implementation of a system for agronomic evaluation of the most advanced lines – variety specific agronomy. This helps to make final choices among candidate lines for release, and adds insight into ways to better manage genotype x environment interaction at the level of commercial production.

Chickpeas:

- Collection of germplasm will occur from around the world with potentially greater levels of ascochyta resistance, earlier maturity and improved seed quality.
- Breeding will target the main objectives of increasing yield, ascochyta resistance, earlier maturity and improving seed quality. In the kabuli market class, cultivars will be developed in both the large (9-10 mm) and small (7 mm) seed size classes, since world markets exist in both. An emphasis will also be placed on whiter seed coat for premium seed coat color for premium markets. In the desi market class, emphasis will be placed on selection for plump (but not round) seed shape and tan or light tan seed coat color. Breeding efforts will be divided approximately equally between desi and kabuli market classes.
- Research will be conducted with the objective of improving canning quality in the kabuli market class. Procedures will be developed to determine the splitting efficiency in the desi market class.
- Research will be conducted with the objective of determining the potential of chickpea as an animal feed.

Beans:

- The shift in growing areas has left the industry trying to keep up with the changes. Ontario requires a greater return on their bean production potentially through specialty markets and value-added. Manitoba, Alberta and Saskatchewan need to develop a basis of strong short season varieties and methods to grow them.
- Bean breeding will focus on yield, closely followed by seed quality. Seed quality encompasses all seed characteristics, physical properties, taste, texture, canning, splitting, hydration, etc. The quality traits are important and vary with different classes of beans. In the short term plant architecture was third in importance followed by disease resistance. In the long-term, upon gaining a greater understanding of the diseases, breeders will be able to place disease resistance ahead of plant architecture in importance. Plant adaptability & stability and cold tolerance were lower in importance because they are more regional concerns and will be a part of the target for yield in those regions.
- Breeding focus will be on kidney & cranberry beans in ON, MB; navy beans in MB, ON; pintos in AB for irrigation, SK and MB for dryland; great northerns & to a lesser extent small reds & pinks in AB for irrigation, SK for dryland; and blacks in ON, AB for irrigation, MB and SK for Dryland.
- Work to develop quality suited for the markets.

Biotechnology

- Biotechnology priorities for pulse crops:
  1. Gene mapping & marker-assisted selection -research results in 1-10 years
  2. Tissue culture –doubled haploidy, transformation and inter-specifics -research results in 5-10 years
  3. Genomics and Bioinformatics- basic sequencing. -research results in >10 years
- The gene mapping & identification and tissue culture areas are both in high importance.
- Although genomics and bioinformatics are considered important, the high cost and lower urgency of this area at this time sets it lower in priority. If there were funds available for genomics that could not be used in other high priority areas of research for pulse crops, then genomics would be strongly encouraged.

- All biotech research should keep the ultimate goal of adding value to the industry through addressing the top objectives developed for the different crops. Freedom to operate is important.
- It is recommended to not have more than one biotech research location per crop to gain the large scale efficiencies and that the location should be in conjunction with a breeding program.
- Metabolic Engineering and Transformation will be addressed as research project areas along with the other genetic improvement project areas.
- When assessing the use of biotechnology, the considerations are whether the project provides betterment to the industry(including markets), whether the objective can be achieved by the natural variability through conventional breeding and does the return to the industry exceed the costs of research (often 5 - 10 million).

New crop & class genetic development plan

- Initiate an effort for new crop or market class development – focus on both new markets for raw product and value added. Quality & Utilization strategy will be used as goals in value added.
- Pulse Canada will support alternative crop development by helping to evaluate the potential of new markets. Germplasm from those markets must be evaluated for Canadian production conditions. There is interest in breeders visiting the potential new markets.
- Develop a germplasm pool source. Find/ survey or analyze existing germplasm that could be used – utilize existing germplasm resources. Explore using mutation for specific targeted traits and other techniques to expand pool.

5. CONTINUED STRATEGY DEVELOPMENT STEPS:

- Move genetic improvement focus to include more emphasis on quality as the programs build to the size where they can handle the work and as the information on quality is generated from the quality researchers.
- Work with the industry to obtain market intelligence that will determine which new crops and market classes have potential future.
- Establish networks with other types of researchers to target and enhance desired traits in crops.
- Emphasize the interdisciplinary approach within programs and between research groups.

Agronomy Research Strategic Suggestions

1. SPECIAL CHARACTERISTICS OF PULSE CROPS THAT MUST BE RECOGNIZED FOR AGRONOMIC RESEARCH:

- Pulse crops are known to be susceptible to diseases. Some locations in the world are no longer able to produce pulse crops intensively due to the appearance of extreme disease pressures.
- Pulse crops are poor plant competitors and therefore weed pressure is a common problem. Weed control products are limited for pulse crops.
- In all cases pulses are considered 'minor' crops. The level of funding and research is based on the minor crops status. The large agro-supply companies view pulses as minor crops and there has been limited private sector work on disease and weed control and there are only a small number of registered products for use in production. Pest control options are very limited.
- Many pulse crops are used for human consumption and only maintain their value if they can be grown and delivered to the market as a high quality product. The animal feed industry is starting to look for and will be paying premiums for certain quality traits that show a positive return to their industry. As a result pulse crops need to be produced and handled much differently than other crops with more focus needed on targeted quality traits.
- Pulses are not only profitable crops but they also provide positive effects to other crops in the rotation.
- Pulse crops are relatively new to Canada. Many of them have been implemented into farming rotations in the last 10 years. Producers are still learning the production system.

2. CURRENT STATE OF AGRONOMIC RESEARCH IN PULSES:

- All pulse crops are seeing an expansion of production into new agroclimatic. There is a need for more agronomic research in areas where there are new pulses to the region. Peas now cover most of the cropland in western Canada. Lentils and chickpeas are expanding beyond the dark brown and brown soil zones. Beans are moving farther north and east in Ontario & Quebec. In the last 5 years , the Red River Valley has become the region with the largest bean production. Bean production has been slowly growing in Saskatchewan and Alberta.
- Dry beans have had more developed agronomic research in Ontario, and to a lesser degree in irrigation zones and in the medium seasoned sub-humid regions in the Red River Valley. The production of beans in short season, dry regions has just begun and will require the development of all basic information.
- Although research has been occurring in peas for a few years, the agronomic research is still in a developmental stage. The amount of information for production of peas is far less than that found for the other major crops (i.e. wheat, barley, canola). Although there are some nearly complete basic agronomic packages for some areas, there are some agroclimatic zones the have only a scarce amount of relevant information.
- Agronomic research in lentils is less developed than peas. Some basic research has been accomplished but there is more information needed, especially regarding the interaction between variables in productions systems and the influences within cropping systems.
- The work in chickpeas is in the infant stages and requires a great deal of work just to gain the basic information.
- Agronomic research activity in pulse crops is limited by a shortage of funding. Agronomists split their time between different crops and the higher funding levels in the other major crops takes research expertise & time away from pulse crops.
- The current agronomic research in most cases is not being analyzed for economic impact. This is a problem found in agronomic work for all crops.

3. IMPACT OF CHANGES IN THE INDUSTRY

- Further increases in the acreage of pulses are expected and with these changes there are new problems developed. One anticipated problem is increased disease pressure. Diseases can spread more rapidly and have more devastating impacts when fields of the same crop are closer together and rotations are shorter.
- The new varieties being produced in pulse crop breeding are developing more diversity in each crop and different characteristics found in different varieties require research to determine the agronomic practices for management.
- Producers need to understand the optimum production practices for their locations to remain competitive. This becomes especially important when growing crops where high quality is essential.
- The level of research activity is often based on historic importance of a crop. The rapid growth in pulse crop production has resulted in a lack of support staff for those who do have knowledge in research and there is the lack of funding to maintain knowledgeable people in pulse research, despite obvious research needs.
- With the increasing importance and emphasis on quality in pulse crops, agronomic research will have to determine how different agronomic practices impact seed quality.
- The black soil zones need more pulse crop options for their rotations. Most areas can only grow peas and some have peas and dry beans.

4. FOUNDATION REQUIREMENTS FOR AGRONOMIC RESEARCH:

- Establish a nationally coordinated effort for pest control. Support collaborations for data collection towards minor use pesticide registration. Note that the researchers are found in federal, university and provincial institutions.
- Canada needs to increase the number of pathologists for pulse crops (one more for each of lentils and chickpeas). Ensure that the pathologist positions assigned to pulse crops are permanent positions – 1 for the short season, moist regions with an emphasis on peas in Alberta, 2 for the longer season and dry region with an emphasis on chickpeas & lentils at CDC, Saskatoon, 1 for the longer season, moist regions with a focus on beans in Morden, part time commitment for pulses in the different ecoregions in Brooks, Swift Current, Lethbridge, Brandon, U of Guelph & Harrow. These positions will involve both basic pathology and support for breeding. Some of the work in these positions has been noted under the breeding section.
- Provide an irrigated land base in primary pathology sites that need it.
- The committee recommends an economic analysis for agronomic projects to determine the economic impact of different agronomic practices to the industry, preferably during development of the project and upon completion. The economic assessment will require data collection and costs incurred and the impact of the management on both yield and quality of pulse crops and overall economics and risk level of the cropping system. There must be production agronomists available to support this approach and funding agencies willing to add more funds in the research projects for economic analysis.
- Develop flexibility in funding to accommodate collaborative research designed according to agroecosystems rather than based on provincial borders or in various institutions. Facilitate coordination of research regardless of the type of institution doing the research.
- Support the development of an inventory of abstracts, reports and workshop proceedings on the systems research. This information should be made available in a searchable form on a web site and/or CD. The information must be kept up to date. Funding needs to be found to compile and maintain this information.
- A database of research would be very useful but the time and cost required for establishing and maintaining a complete database needs to be determined.
- To maintain our competitive advantage in the production of pulse crops, there must be a strong presence of agronomic research that focuses on risk management. To reduce the risk in pulse

production, there must be a continued building of knowledge to address issues in all aspect of production such as: disease control, integrated pest management, variety testing & adaptation, weed management, intensive pulse crop rotations, herbicide registration, pathogen race surveys, pathogen mode of action, inoculation, fertilization, seeding procedures, harvesting techniques, irrigation production, dryland production systems, organic production, pest biocontrol and insect control.

Foundation Funds Required for Agronomy

Pathologists - 3 new and part time positions		$ 1.5 million/ yr
- Set up costs		$ 1.0 million
Total Agronomy foundation needs	- ongoing	**$ 1.5 million/ yr**
	- one time	**$ 1.0 million +**

This total is relatively small because the people and infrastructure are already in place. The largest area in need of an influx of funds is in the areas of research listed. This would allow the balance of research to shift to the appropriate level of work on pulses.

5. ISSUES IN AGRONOMY

In the process of determining issues and needs in agronomic research for pulse crops, there were two dominant areas that consistently arose: disease and weed management. These areas should always be rated highly in pulse crops because by their nature they are susceptible to diseases and are poor plant competitors. Many areas around the world have lost their ability to grow pulse crops because of increasing disease pressure. It is therefore important to not only maintain and develop control measures for the current disease problems in each crop and region, but to be proactive in monitoring for new potentially dangerous strains and diseases. Obtaining crop protection product registrations is a common problem.

Agronomic research needs to provide risk management to producers to maximize economic return. The research should show how to reduce the cost of inputs while keeping or expanding the return and show how much risk is associated with different farming practices.

The following is a list of current problems or issues in pulse crop production and some points on how to deal with them:

5.1 Peas

Disease Management:

- Mycosphaerella / Ascochyta Complex
  - Control will likely be more successful through agronomic studies than breeding.
  - study yield models to see how good they are.
  - Develop a scoring system for producers from threshold data
  - Much base work has been done in France that we can use but we need yield response in Canada. How much yield? Quantitive or qualitive?
  - Farmers are reluctant to spray-they feel it doesn't pay because the crop can look bad but still produces a decent yield-economic threshold is needed
- Soil Borne Pathogens – Root rots
  - Becoming more of a problem with time because they build in the soil.
  - Establish thresholds, production/yield data. Study yield models

Quality

- Green peas are not grown because of too much bleaching in some areas -Need some innovative ideas-Study altering the production system to retain color – i.e desiccant use.
- Amino acids protein variability- unknown market benefit if developed.

Farming Practices

- P, S & K-especially with early seeding
    - Isolated trial information out there -Need to fill in gaps i.e. missing soil types and pH levels / osmotic interference on seedlings/ target areas with lower soil organic matter
    - Economic yield reductions
    - Research-new run of seed placed fertilizer trials with modern practices
    - Target-eco-regions with various soil types
    - Impact of manure applications –larger applications during rotation
- Inoculants - Growers complain they don't get their money's worth out of inoculants Don't want to overlap with what Alberta has done
    - Proper inoculation -how long will bacteria survive once inoculants applied? -.
    - Consider an inoculants rating system like that in Guelph for soybean.

Yield variability

- It is recognized that there are large unexplained variability in pea yields.
- Suggestions for the differences -crop rotation, microorganisms in the soil
- Need to look at entire picture and how to maximize the genetic potential
- Determine the impact of: Mycosphaerella -yield loss
  Soil nutrient package
  Water & heat index
  Microbial below ground (VAM & root rot impact)
- Use a survey of growers to determine the successful farming practices that are used by the top yielders – in person interviews- or possibly by internet.
- Approach the problem through both the producer survey and through field studies. The producer survey will likely provide some answers and certainly provide some indication of the factors to target in the field study.

5.2 Lentils

Disease Management:

- Ascochyta & Anthracnose
    - Pathogens-monitor plant health– may have good resistance to these diseases but monitor for new virulence or new disease problems.
    - Need to urgently establish the facilities to do research, disease nurseries, labs, etc.
- Root rot-increase in areas where pulse rotations are tight.
- General monitoring of plant health applies for all diseases. - Study any new disease pressures.
- Sclerotinia & Botrytis
    - Happens with wet conditions
    - No pesticide is registered
    - Management practices-test for a few more years
    - Yield loss data on these diseases.

Quality

- It is unknown what the importance agronomic factors have on quality – could look at harvest management and pest management.

Farming Practices

- Fertility-P-S - fill gap regions - update to current seeding systems. Impact of manure applications
- Inoculation- proper inoculation -how long will bacteria survive once inoculants applied? -Drier regions so more of a challenge - Growers complain they don't get their money's worth out of inoculants

- Develop a new management system for new plant type of lentils being bred.

Seeding/Harvesting

- In order to respond to splitting industry needs, study lowering the moisture levels during harvest without damaging the seed-red lentil, desi's

5.3 Dry Beans

Disease Management:

- Sclerotinia -Fungicide use
  - Research application technology-spray coverage tests with producer equipment
  - Economic threshold assessment
- Bacterial Blight
  - Short-term
    - Use disease free seed (isolated location for production in Canada can be considered)
    - fungicide efficiency and economics
  - Long term
    - Breeding resistance
    - Pulse Canada should encourage CFIA to adapt their rules to match those around the world for interspecies crosses.
- Soil Borne -Root Rot
  - Seed treatment for early season control covered by the chemical companies. Continue working with the chemical companies for development.
  - Recognize as issue that is difficult to address.
- Anthracnose
  - Seed treatment is critical-registration support is needed
  - Continue development of plant resistance is the key
  - Breeders should test all new lines for 3 major strains-alpha, beta and gamma
  - Monitor disease populations for race changes - Identify races regularly
  - Educate on easy spread
  - Important not to ignore anthracnose because it is a sporadic disease that cause huge yield and quality losses.
- Rust
  - Sporadic attacks-breed for long-term resistance
  - Use foliar fungicide for the short-term

Resistance and fungicides are the methods for disease management in bean.

Insect Management:

- Potato leaf hoppers
  - Dominant and regular problem, especially in Ontario but are seen in Manitoba as well.
  - Threshold study for potato leaf hoppers
  - Basic entomology– what is the attraction to beans by leaf hoppers
- Several other insects are attracted to beans but are sporadic problems-Ontario has problems with seed corn maggots, wireworms, soybean aphid, bean leaf beetle, stinger; Manitoba with cut worm
- Insecticide-minor use is issue-keep the chemical available (registered).

Farm Practices:

- Developments are required for narrow row grain systems in the prairies
  - Even seed spacing and depth are critical in beans-is also a factor in pest management
  - New equipment will have to be designed (when it is not being done by manufacturers or when farmers are unable to)

- Depth control is critical
- Manufacturers see no point in investing money into designing a machine for pulse crops unless there is a specific machine, and then they would build it

Quality:

- Avoiding frost at the end of the season for short season areas
- Desiccation –timing needs to be studied
- Even maturity is a major factor for quality – to achieve an even maturing crop it requires an even seedling emergence (partly seeding control)
- IP system-way of future - need protocol -IP system demands quality
- The industry doesn't have a very good handle on quality need to look at it more in agronomy
- Size, color and seed coat damage are the major issues
  - Can be lost in single harvest technique

Sustainability:

Soil Erosion

- Especially apparent when beans are in rotation with potatoes
- Beans in standing cereal stubble reduce erosion

5.4 Chickpeas

Disease Management:

- Ascochyta
  - Yield loss data (economics)
  - Monitor pathogen population
  - Disease management systems
  - Fungicide -minor use registration
  - Decision support system
  - Application technology/ air application vs. ground application
- Sclerotinia and Botrytis
  - Yield loss data
  - Disease management strategies
  - Product availability
- Root Rot
  - Seed treatment studies in collaboration with chemical companies
- Minor Use registration needs to be encouraged at the national level.

Farming Practices:

- Fertilizers & Inoculants
  - What should be the soil-testing recommendations parameters?S & P- develop a production package —to N Fertilizer or not
  - Inoculation-Rhizobium survival -Field studies on interaction of inoculant with seed treatment

Quality

- Problems -Delayed harvest (regrowth), loss in color, and shrunk, smaller seeds
- Harvest management of chickpea
  - maturity of plant
  - potential to swath
  - desiccation practices - Timing of desiccation treatments not available
  - let it freeze?
  - Establish for dry-land and irrigated areas

Crop management systems

- Need to build experience - a baseline - Many new questions appear regularly
    - Establish optimum seeding rates
    - What is the better crop rotation?
    - Soil erosion issues in crop rotation
    - Need to consider the different types and architectures – may need different management practices
    - Kabulis have many pods with no seeds –potential to improve yield with practices?
    - Fall seeded desi

5.5 New Crops

- Faba beans-food and silage
- New classes of beans
- Market possibilities should be determined before any research is initiated.
- Agronomy packages should be started as being developed.

5.6 Weed Management

All of the crops faced the same major issues in weed management:

- Develop Integrated Weed Management
- Rotations -Need to get the field clean enough to grow these crops – full rotation/crop system studies
    - Need research to figure out optimum crop rotation
    - Educate producers of low competitiveness of pulse crops
    - Practices to help reduce pesticide use especially for lower valued crops like peas

- Herbicide
    - Products are being lost and very few new products are coming. New products usually spin off soybean work. With the expansion of Round Up Ready soy companies have cut all herbicide development programs. We won't see anything for at least 5-10 years. There is very limited support from companies for research into getting current products labeled for pulse crops.
    - Broad leaf weed control
    - Soil residual issue -develop safe rotation practices and management and use practices.
    - Find broader spectrum control-nothing is registered
    - Encourage product registration
    - Problem of dry bean variety specificity and market class specificity to herbicides

5.7 Integrated Research

Minor Use Registration

Minor use issues

- Most chemical companies will not consider registering a pesticide for a crop with less than 10 or 20 million acres. In the world scale, pulse crop production is small and so it is very difficult to get research for the use of chemicals on pulse crops. To gain more recognition from chemical companies it is strongly recommended that Pulse Canada take on a lead role. Currently individual researchers or provincial employees approach the chemical companies individually. A national unified approach would provide a much stronger argument and therefore would increase the rate of success.

- Complexities within PMRA for minor use registration create further hurdles to providing registered products for pulse production. Further harmonization with the US and Europe is required. -
- There is an issue of how large do crops have to get before PMRA considers it to not fit in minor use anymore. Chemical companies evaluate whether they should register a product based on their risk and profit. The definition of what is not worth registering differs for all companies. PC has to be careful not to brag pulses right out of minor use status. The PMRA category of minor use should be changed to apply when the chemical company does not have interest registering the product for this use.
- Producers will find a way to use the chemicals available for the major crops whether they are registered for the minor crops or not because they need the tools.
- There are pest research opportunities that are difficult to address because of the sporadic nature of the problems. You don't know when you will have the problem and therefore it is nearly impossible to acquire the funds needed to do the research.

Establish a Sporadic Pest Research Fund.

- Emergency research fund for use when opportune conditions appear for studying pests (likely disease or insects) where a sudden and dramatic change has occurred.
- Coordinated by a pulse minor use registration committee
    - Keep the group small to make decisions fast.
    - Scientists should be on the committee to decide what research needs to be done and how
    - Suggestion of 1 pest person and 1 weed person / province
    - These people will be the point person to discuss funding projects with other provinces and then to take back to the people in their province.
- Set up a slush fund with Pulse Canada - they could react more quickly than a Government
- The Government will want protocols set so they can feel comfortable that their funds are going to be used effectively– i.e. a set level of funding
- Research protocol should be preset where applicable – established by the committee.
- The committee will establish an amount $/yr over a set period of time. The fund will be a slush fund that builds or is used depending on the varying needs from year to year.
- Keep communication with and knowledge open to minor use efforts in other crops and countries so that collaborated efforts can expand beyond pulses and/ or Canada.
- Guidelines
    - For sporadic pest outbreak research
    - Must be economically feasible and growers interested in applying the product
    - If there is a pesticide involved, that it has a chance to be registered some day
    - Follows the protocol in place on how the research is done.
    - Use guidelines set up for emergency registration of minor use products
- Consider approaching provincial governments, Universities or private contractors to do the research

Integrated Pest Management

Pest control is a huge issue across all eco-regions. When dealing with Pulse Crops-few chemicals can be used -need to deal with these problems in the rest of the rotation- some producers will grow Pulse crops on any type of field no matter how dirty. Pest control is a big negative economic factor in pulse crop production. It creates high risk. Currently there is little money for systems type research because it is long-term.

Issues in integrated weed management

- The goal is to increase net return by maintaining low weed populations throughout the rotation. Pulse crops are the weak link in chain. Use chemicals through the whole rotation to keep control.

- Study biology of the major perennial and annual weeds. Target preventing establishment of perennials and limiting annual broad leaf emergence.
- Study the impact of plant spacing and populations.
- Herbicide residue problems – crops before and after the pulses
- More research on the impact of changing the cropping systems/rotation for integrated weed management
- Research has just started into using intercropping in feed production as a means in integrated pest management – promising results.

Integrated Pathology Research

- Rotation effects on root rot and other serious pulse diseases that have been described earlier.
    - How many years between pulse crops? Risk associated with different rotations.
    - Impact of type and timing of crops between the pulses.
    - Impact of new, commonly used rotations on disease.
- Ascochyta in Chickpea – establish a study considering the:
    - What impact does the common cropping systems have?
    - Determine the profitability of the systems
    - Can the pathogen survive on other crops in the rotation?
    - Impact of varying row spacing
    - Fungicide application technology
- There is a need to perform biological research on new diseases before you can do anything else about it. eg Sclerotinia and Botrytis.
- Disease forecasting systems can be developed in the long term – this comes after establishing the impact of all major variables -need model and weather data systems etc.

Systems research

- Risk management-develop the information needed for producers to estimate the risk they are going to take when making different choices in crop rotation.
- Understanding the complex interactions between variables in rotation systems are important-farmers want to know what they should be doing and the potential impact of it in the long-term. The rapid change of farming practices makes it a challenge to perform multi-year work that remains representative of farming.
- Environmental-water, soil erosion, nutrient management, etc. should be included in the systems studies.
- The Sustainable Environment committee has established a comprehensive list of cropping system type research areas.
- Facilitate common protocols-so the data can be combined across different studies and ecoregions –more cost effective manner than what is happening now.

Risk Management Research

- For each climatic zone or ecoregion:
- Measure how the key factors of disease & weed control are influenced by changes in inputs – control water and measured heat units.
- Estimate relative risk with in each of the systems so the producers can chose what system is best suited for their operation
- Potential yield & quality
- Impact of non-purchased inputs-rotation, management, investing time (knowledge) and purchased inputs -fuel, tillage on seeding operation, fungicides and herbicides (money)

There are many questions in the regions with new crops. For example in the brown soil zone-the interactions between chemical residue from different types of crops, crop frequency, crop sequence, summer-fallow, nutrient use efficiency on crop yield & quality, disease and weed pressures.

6.0 CONTINUED STRATEGY DEVELOPMENT STEPS:

- Creating a plan to integrate pulse research with other crops' research in a more coordinated manner.
- Develop a support system that can provide agronomists an economic analysis for their research. i.e. develop a list of economists that are willing and capable of providing an economic analysis on agronomy projects.
- Facilitate research collaboration in disease, weed management and other general uses of pulse agronomy.
- Develop a Pulse Crop Minor Use Pesticide national plan. Establish a committee that represents the researchers and works closely with the provincial minor use coordinators.

Environmental Sustainability Research Strategic Suggestions

1. SPECIAL CHARACTERISTICS OF PULSE CROPS THAT MUST BE RECOGNIZED FOR ENVIRONMENTAL SUSTAINABILITY RESEARCH

Canadian pulse products have a tremendous potential to be sold as an environmentally friendly product. Factors that make pulses appealing from an environmental perspective are that pulses fix their own nitrogen, pulses appear to directly benefit other crops in the crop rotation, and pulses may improve soil quality when grown appropriately. These factors are important to foreign and domestic consumers of Canadian pulse products who are increasingly concerned about the environmental impacts of food production. Thus, an opportunity exists to position Canadian pulse products favourably in high-value environmentally conscious markets. The pulse industry must document its environmentally sustainability to make its claims creditable and investing in research into environmental sustainability will be necessary in international trade for proving that pulse production meets environmental safety requirements under the WTO. Pulse cropping systems can be made more environmentally attractive and sustainable by addressing erosion concerns following pulses due to their relatively low crop residue production, improving nitrogen fixation through better management, minimizing nutrient losses in pulse-containing crop rotations, and reducing pesticide use during pulse production. Canada can be proactive and position its pulse industry on a firm foundation of sustainability. Research to develop cropping systems with pulses that are environmentally appropriate bestows economic benefits by minimizing problems (reduce costs) and providing the most efficient and effective production (reduce risk and increase returns). In short, research into environmental sustainability is an essential part of the scientific foundation upon which to build a long-term competitive and successful pulse industry in Canada.

2. CURRENT STATE OF PULSE ENVIRONMENT & SUSTAINABILITY

Canada is well regarded for the importance it places on environmental sustainability of food production. Fundamental to this has been research investments into understanding environmental sustainability. Although relatively few in number, the government and university researchers involved in environmental sustainability of agricultural systems within Canada have a well-earned reputation for conducting farmer-relevant cutting-edge research. The public has largely supported this research with limited contributions from industry. Unfortunately the rapid growth in pulse production over the last decade has corresponded with flat to declining public research funding. Canadian research into environmental sustainability regarding pulses in cropping systems is limited and, for some important topics and climatic areas, essentially no research has been conducted. Further, there is very little relevant research into the environmental sustainability involving pulses in the U.S. and elsewhere in world with somewhat similar climate to Canada as pulses in those areas are only minor crops. Hence, describing and ensuring the environmental sustainability of pulse production will require new research funding.

3. FOUNDATION REQUIREMENTS FOR ENVIRONMENTAL SUSTAINABILITY RESEARCH

The four features of the environmental sustainability research strategy are long-term, holistic, relevant and linked, and strength- enhancing.

3.1 Long-Term

The research into environmental sustainability has to have a long-term (> 5 yr) program. A fundamental component of the long-term program needs to be the maintenance of existing studies and setting up of new long-term cropping system experiments involving pulses. The network of these long-term experiments is necessary to address current and future issues in environmental sustainability. This long-term experiment network must cover all-important climatic areas with pulse production in Canada and

cover the relevant pulse types. The long-term goals will be largely addressed through a series of shorter-term (2-5 yr) projects.

3.2 Holistic

The research program has to consider pulses as part of much larger cropping system involving sequences of crops and management practices over time. The environmental sustainability of the entire cropping system is relevant for the interactions between every crop in the rotation not just the pulse component. Pulses can take the lead in developing the sustainable environment studies but it is important to achieve the buy in of other commodity groups to achieve the goals. The pulse strategy can place the pulse industry in the lead, which is important since we have the most to gain.

Research into sustainability must also address the production economics of the cropping system. In addition to support from the pulse industry, funding on environmental sustainability should also come from other sectors of the agricultural industry as well as from the public.

Projects will ignore provincial boundaries and focus expertise to provide the best and most comprehensive information as quickly and efficiently as possible to the industry.

3.3 Relevant and integrated

To be adopted, environmentally sustainable farming practices must also provide short-term economic and agronomic benefits. Hence the research into environmental sustainability needs to be integrated with agronomic research addressing practical shorter-term benefits. The economics risks and returns of the pulse cropping system will be an important factor in the research program. The research into environmental sustainability also needs to be linked with breeding research so that the breeders can be made aware of opportunities to make pulse production more sustainable through breeding and so that the environmental implications of new pulse cultivars can be considered

3.4 Strength-enhancing

The research program will build on the existing informal network of researchers involved in environment sustainable research in collaboration with pulse specialists and pulse agronomic researchers. It is important to network the researchers that have done some work on pulses as the starting point from which to build the research program. The research will strengthen our knowledge base through a mix of applied research with that which probes more deeply into the underlying principles.

Additional human resources will be required to undertake the necessary environmentally sustainable research. Most of this human resource will be provided through short-term appointments of graduate students, post-doctoral fellows, and contracted or term scientists. Indeterminate researchers who study environmentally sustainable production and who are dedicated to pulses alone, are not required due to the nature of the research working across a number of crops. However, supporting the addition of indeterminate researchers to public research institutions is required to expand existing strengths and to address all the required research. An important part of strength enhancing will be to sponsor regular workshops and conferences on environmental effect of pulses, otherwise the pulse-specific issues tend to be lost among those of other crops in existing forums of research information exchange.

4. ISSUES IN ENVIRONMENTAL SUSTAINABLE PRODUCTION OF PULSES

The research can be divided into three general research areas:

1. Greenhouse gases,
2. Crop management, and
3. Cropping system management.

4.1 Greenhouse Gases

Rationale and Potential Benefits to Pulse Industry

The recent (July 2001) agreement to rules of the Kyoto Protocol and the anticipated ratification of the Climate Change treaty will force Canada to achieve a reduction in greenhouse gas (GHG) emissions by 2008. Pulse production helps to reduce greenhouse gas emissions because they fix their own nitrogen supply from the atmosphere. Not requiring nitrogen fertilizer avoids the emissions associated with production, transport, and application of nitrogen fertilizers. Some of the pulse crop fixed nitrogen can carry over into the following crop and thereby provide further reductions in nitrogen fertilizer in the cropping system. However, despite these potential greenhouse gas benefits, using current methodologies for estimating the GHG effects, these benefits are not captured. Using current methodologies, pulse crops are assumed to have roughly equal GHG emissions as other crops and, in fact, in areas where relatively little nitrogen fertilizer is used, pulse crops are assumed to have higher GHG emissions than other crops. There is some documentation indicating that the pulse crop residues, which often have higher nitrogen concentration than other residues, are more efficiently converted into soil organic matter and thereby pulse crops act to increase total soil organic matter. In this process, the CO_2 used from the atmosphere by the pulse crops becomes carbon sequestered in the soil. However, insufficient information is available to have these pulse GHG advantages considered in potential Canadian GHG mitigation policies. In short, pulse crops are probably an environmentally positive regarding GHG, but, without appropriate research, this potential benefit to the pulse industry will not be recognized.

Pulses are sensitive to weather. The current Canadian climate makes pulses an attractive crop but little is known how future climate change will affect pulse production

Greenhouse gas and climate change issues and required research

Issue	Current Situation	Research Needed	Research Linkages
4.1.1 Lack of knowledge in work on GHG emission for pulse crops	Research exists in the world literature and some work is underway now in Canada but it needs to be pulled together	Search and summary of relevant published, unpublished research, and current Canadian research involving GHG effects (N_2O and C sequestration. The deliverable must include a identification of gaps and opportunities	National project required. Summary of document sent to policy makers on GHG emissions from agriculture.
4.1.2 N_2O emissions from pulse crops	Almost nothing is known about the emissions of this important greenhouse gas from pulse crops under Canadian conditions. Currently pulses are considered neutral to bad although there are indications that they are good to neutral	Quantification of the amount and timing of N_2O emissions from pulse crops and their residues for all major pulse crops across relevant climatic zones and a range of conditions	Research relatively short-term and, given limited expertise available, needs to be conducted at universities and government labs. To evaluate N_2O emissions from residues will require studying the effect within a cropping system.

4.1.3 Carbon sequestration from pulse crops	Some assume that pulses reduce soil organic matter because they produce relatively little crop residue. However, scant information suggests that pulses may increase carbon sequestration because of their relatively high input of nitrogen	Quantification of the benefit of pulse crops on C sequestration for different pulse crops, soils types, climatic zones, and cropping systems.	Combined approach of short-term (<5 yr) research on C&N dynamics plus longer-term cropping system studies.
4.1.4 Total pulse crop impact on GHG	The holistic benefits of pulses on GHG in cropping systems is not well understood or documented	Develop GHG budget for pulse production systems. This would be a project after other research /above research is completed.	Research will require research results from other /above research and may involve models on GHG emissions. Results to be used for policy development
4.1.5 Adaptation of pulse industry to climate change	We have no understanding of how expected climate change will affect pulse production in Canada. Developing this information is complicated by the fact that we need better understanding of the effect of weather on the growth, N-fixation, and grain yield of pulse crops generally.	Develop relationships that describe the effect of temperature, water availability, and atmospheric CO_2 concentration on the growth, N-fixation, and grain yield of pulse crops. Use these relationships with future weather and atmospheric CO_2 concentration scenarios to predict how climate change may impact pulse production and pulse cropping systems across Canada	This research will provide important information on pulse physiology and growth response that will help pulse agronomists and breeders. Information as to the impacts of climate change on pulse crops will provide guidance to breeders as to optimizing cultivars for future conditions.

4.2 Crop Management Issues

Rationale and Potential Benefits to Pulse Industry

Research into management practices can address particular environmental problems that may result from erosion or pesticide use. This research can also further develop positive environmental and sustainable impacts by pulse crops.

Crop management issues and required research

Issue	Current Situation	Research Needed	Research Linkages
4.2.1 Maximizing the cropping system N benefit from pulse crops	Many of the environmental benefits of pulses stem from their N fixation so maximizing that fixation makes pulses a more attractive crop from an environmental perspective. This is and has been an	Research into the impact and long-term management of fixation – nutrient interactions, interaction with crop type preceding and following the pulse crop, optimum long-term rhizobia	Links closely with agronomy research; add measurements of N fixation and carryover of N to the following crops to on-going and

	important area of agronomic research. However, this has not been well studied from the viewpoint of the cropping system.	management in a cropping system	future agronomy research
4.2.2 Wind and water erosion	The limited residue returned to the soil by pulse crops may be a risk for erosion. We know in general the erosion risks and ways to minimize erosion risks following pulse crops. However, more specific work is needed, especially for dry bean and, to a lesser extent, for chickpea	Specific research into minimizing erosion risks through management practices and cropping systems. (Research into effect of pulse crops on soil aggregation is discussed under cropping system management.)	Links closely with agronomy research and to a lesser extent breeding research to devise soil-ecozone-specific management practices and varieties that do not leave the soil in an overly erodible state.
4.2.3 Reduced environmental impact of pollution from nutrients and/or pesticides.	There is no research information to refute the claim that pulses contribute to excess nitrogen that causes pollution of surface and ground waters in Canada. We do not know the magnitude of the pesticide pollution risk as affected by pesticide type, pesticide management, and interactions with landform, soil type, and climatic zones.	Effect of production management on the amount environmental pollution from nutrients or pesticides fir different pulse crops, soil types, land forms (e.g. land with depressions versus more level land), and climatic zones	Links to existing pulse agronomy research and longer-term cropping system research

4.3 Cropping System Management Issues

Rationale and Potential Benefits to Pulse Industry

Many of the environmental advantages of pulses are derived from their benefit on the soil and on other crops within the context of a cropping system. Developing a better understanding of the nature of those benefits can maximize the return from entire cropping system. Compared with other crops, pulses are reported to improve soil carbon and nitrogen dynamics. Pulses can only be assessed for environmentally sustainability when studied in long-term cropping systems that are appropriate for the soil type and climatic zone.

Cropping Systems Management issues and required research

Issue	Current Situation	Research Needed	Research Linkages
4.3.1 Long-term cropping system experiments	There are relatively few long-term cropping system experiments with pulses. Researchers in this field can	Prepare an analysis of opportunities and research gaps regarding long-term cropping	Many long-term cropping system experiments started as agronomy

are essential to address environmental sustainability issues	be unaware of all the medium-term experiments. All these experiments are continually threatened with elimination due to budgetary pressures.	system experiments including an inventory and description of existing medium (4-10 yr) and long-term (> 10 yr) cropping system experiments having pulses (or legumes). Build and maintain a network of long-term cropping system experiments covering all important pulses and pulse production zones.	experiments and so ongoing medium-term agronomy experiments will be included in the inventory
4.3.2 Rotation effect on soil	We really do not understand how to manipulate the pulse cropping system to maximize the rotational benefits on the soil and minimize any rotational problems caused by pulses. Pulses are often described as soil building but the aptness of this statement needs to be documented across pulse crops, soil types, and climatic zones in the context of cropping systems.	Holistic set of studies into the soil quality (physical, biochemical, biological, nutrient cycling and soil organic matter dynamics) benefits from pulse crops on soil across pulse crop types, soil types, and climatic zones. Targeted short-term (lab) and longer-term field studies.	This research needs to be relatively long-term beyond most conventional shorter-term agronomy research. The research supports other areas including agronomy and greenhouse gases
4.3.3 Non-soil rotation effects of pulses and on pulses (weeds, diseases, insects, yield, seed quality)	Pulses have large effects on and are affected greatly by the cropping system. Many "rules of thumb" have been developed from past research. However, there is no comprehensive information on this topic, especially considering longer-term effects.	Studies to document how various pulse cropping systems affect diseases on pulses and other crops in the rotations and the effect on weeds and insects. Studies into the effect of cropping systems on pulses yield & seed quality.	Links strongly with agronomy research but requires a longer-term cropping systems approach. Also links with breeding and quality (diseased seed) research.
4.3.4 Reducing pesticide and fertilizer use including organic and pesticide-free pulse production	Reducing pesticide and fertilizer use has become an important issue for society and for cost-conscious producers. There is increasing international and domestic consumer demand for pulse products grown without pesticides and quick-release fertilizers ("organic"	Studies into methods to reduce pesticide and fertilizer use in cropping systems. Studies into pulse production without pesticides or chemical fertilizers	Links with agronomic research on same topic

	production) or without pesticides in the pulse year (pesticide-free production). Although reducing pesticide use is an ongoing agronomy and breeding objective, we do not have a complete understanding of methods to reduce or eliminate pesticide and fertilizer use in the context of a cropping system. Principles learned in this research benefits all pulse producers.		
4.3.5 Production economics of pulse-cropping systems	Relatively little research has been done on production economics of cropping system that also includes both production and market risks. It is particularly complex for pulses because of the strong rotational effects. Growers need this production economic information to make decision regarding the economic benefits of more environmentally sustainable pulse-cropping systems	Research into production economics of pulse-cropping systems based on existing data from long-term experiments	Links with agronomy research.
4.3.6 What are the important cropping sequences and practices used by growers?	Targeting research requires knowledge of the current production practices of growers	Survey pulse growers as to cropping sequences and production practices	Links with agronomy research

5. CONTINUED STRATEGY DEVELOPMENT STEPS:

- Consider whether there are any environmental issues to be addressed in processing.
- The pulse industry should contact the other commodity groups and try to work together in whole cropping rotation studies.

Pulse Crop Research Area List

The scientists have developed a list of key research areas (Please see Appendix I) that address the major issues for pulse crop research. This list needs to be examined on whether it is complete. All of the research areas listed are important and should be addressed over time. The researchers have prioritized the research areas in their discipline because they recognize that all of the work cannot be done immediately. The priority list may have areas where it is inconsistent or inaccurate when looked at as a whole because the ratings listed were done on individual research areas and then compiled into one list.

Pulse Research Strategy Workshop

It will be up to the whole industry, the people attending the workshop to develop the strategy for research in pulse crops. A list of invited workshop attendees can be found in Appendix J. The information above provides some thoughts of pulse researchers and can act as a starting point for discussion. The workshop is the pivotal point for sorting out the strategy for the industry and how we intend to implement it.